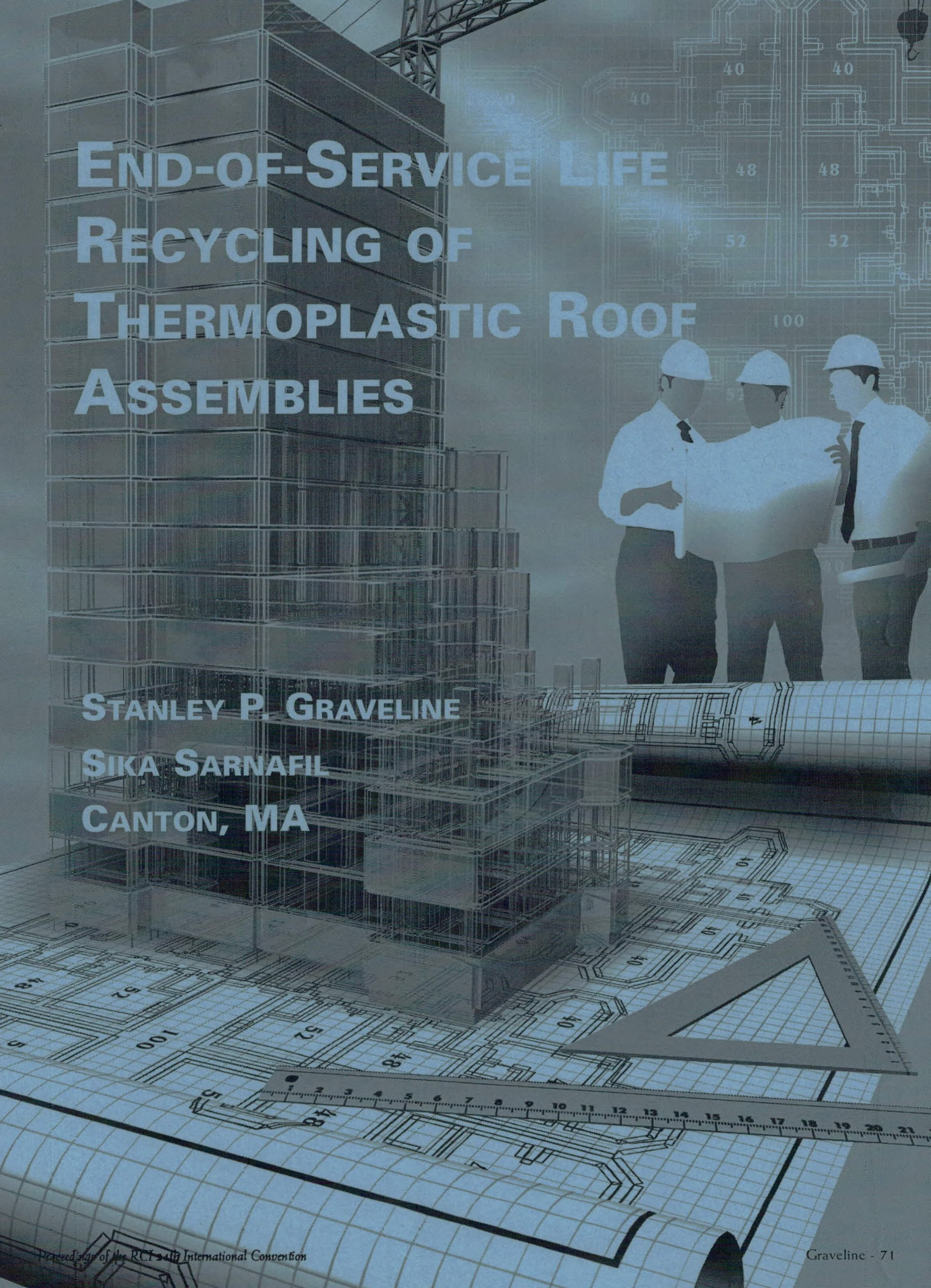

End-of-Service Life Recycling of Thermoplastic Roof Assemblies

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ABSTRACT

Municipalities are increasingly limiting the disposal of construction waste. As roofing material makes up a significant part of construction demolition waste, consultants and other designers need to know the current state of the art regarding both post-industrial and post-consumer recycling of roofing materials. Case studies will illustrate what can be achieved in recycling various insulation materials and thermoplastic membranes during construction and at the end of service life. Obstacles to be overcome, potential solutions, and economic viability will also be addressed.

SPEAKER

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INTRODUCTION

To state that there are as many definitions of sustainability as there are people reading this paper would only be a minor exaggeration. However, most, if not all would probably agree that recycling is a key component of any concept of sustainability. It is something that has been ingrained in our psyches for some time. Who can remember a time before the "blue box" (or whatever color your city or town uses) curbside collection of newspapers, cans, bottles, etc.? Recycling is now a big business in the U.S. According to the National Recycling Coalition, there are 56,000 recycling operations in the U.S., employing 1.1 million people, with a collective annual turnover of $236 billion – a figure that apparently now exceeds what the trash disposal industry takes in. The bulk of this activity is taking place in the consumer goods industries.

Unfortunately, although there have been a few notable success stories such as carpeting, recycling is far from mainstream in the construction industry. Some jurisdictions, such as the City of Chicago, are beginning to mandate recycling and other waste diversion approaches. Typically, these programs are geared towards concrete, masonry, and other bulkier materials. The United States Green Building Council (USGBC) and the Green Building Initiative (GBI), through their LEED and Green Globes standards, promote recycling and the use of recycled materials.

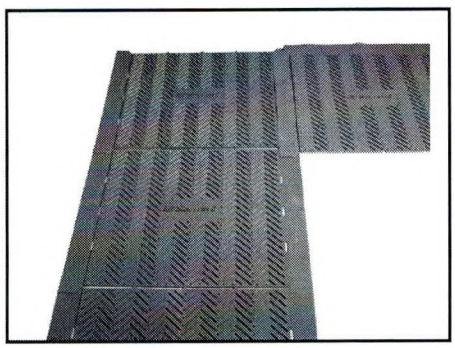

Figure 1 – Walkway pad made from 100% preconsumer-recycled PVC membrane.

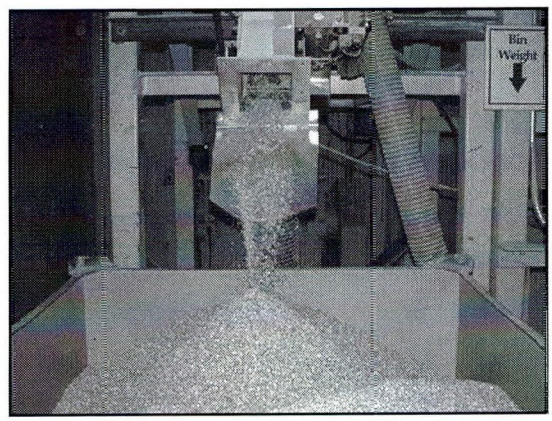

Figure 2 – Granulate from recycled vinyl membrane.

To date little has been done in the commercial roofing segment. The members of the Chemical Fabrics and Film Association (CFFA) are taking a leadership role in the development of recycling programs for thermoplastic PVC roofing membranes.

PreConsumer PVC Membrane Recycling

PVC has an inherent advantage over many other roofing materials with regard to recycling. As a true thermoplastic, it can readily be heated and reprocessed without loss of key physical properties. PVC membrane manufacturers have, over many years, diverted many millions of pounds of production trimmings from landfills into a variety of innovative products. One company has developed a line of commercial and industrial flooring products that is made exclusively from its roofing membrane production scraps. They also produce concrete expansion joints from the same material. Another company produced walkway pads (*Figure 1*) that can be welded into place on the base roofing membrane.

Combining state-of-the-art grinding and separation technology with the newest membrane production lines has enabled some companies to take the process to another level. Grinding equipment is now available that can separate polyester scrim reinforcement and felt backing from the polymer. Production lines designed to process the resulting granulated vinyl material (*Figure 2*) allow for it to be blended with virgin feedstock into new membrane. With the ability to achieve loadings of preconsumer-recycled product of up to15% by weight in new membranes, one manufacturer has greatly increased its volume of recycled material. Whereas the production of walkway pads consumed a few hundred thousand pounds of product a year, now millions of pounds are converted back into new membrane annually. The process has been so successful that the manufacturer has ceased production of the walkway pads.

Figure 3 – Polyester scrim, felt backing separated from the PVC membrane for recycling.

Residual scrim fibers and felt backing (*Figure 3*) from the grinding process are being used to reinforce concrete landscaping blocks. This integrated approach has resulted in achieving essentially 100% conversion of raw materials into usable products.

The most obvious extension of such a program would appear to be the collection and processing of site trimmings. The various remnants that are typically generated on any single-ply roof are ideal for recycling in the case of PVC membranes. Generally clean and uncontaminated, they can be processed in the same manner and at the same levels as production trimmings. The challenge lies in accumulating them and returning them to the production location. A number of regional trials were conducted by one manufacturer in the spring and summer of 2008 (*Figure 4*). Although the program was enthusiastically received by many of the contractors approached to participate, it achieved only modest success. Translating the contractor management's support into action in the field is a major challenge. On an average 25,000-sq-ft project, there may be at best (at worst, considering we are discussing waste material) a couple of hundred pounds of scrap. Most pieces are small and distributed throughout the roof area, primarily around penetrations. The technicians see little if any value in

Figure 4 – Collection of site trimmings.

either hauling bags around to collect these scraps or in picking them up and bringing them to a central collection area on the roof. Their focus is on performance, and sorting small amounts of debris by type is understandably not a high priority. Various incentives have been considered, but to date, nothing has been found that is commensurate with the value of the material being collected yet is sufficient to drive behavior.

In instances where contractors were able to motivate their crews to participate, the bags of trimmings were brought to the manufacturers' local warehouse, where they were stored until a sufficient quantity was accumulated to merit shipment to the production location. Some contractors delivered the bags themselves, and in some regions, field technicians picked up the bags during final inspections.

Figure 5 – Asphalt patching compound produced from postconsumer vinyl membranes and other recycled plastics.

Such a program can only have a significant impact with broad participation by the contractor base. Not surprisingly, in the limited trial, contractors that already have a strong ecological focus and commitment were more easily able to get their field people onboard. Such a program cannot be successful in isolation. It must be part of a much broader series of initiatives within a company to gain any real traction.

Figure 6 – PVC membrane packaged for shipping to recycling plant.

Figure 7 – Gaylords being shipped to the recycling processing facility.

Postconsumer Recycling

The "holy grail" of any waste diversion program is end-of-service life recycling. Although important initiatives, the reclamation of plant trimmings and construction site remnants represent only a tiny fraction of the hundreds of millions of square feet of membrane produced and installed annually.

One company was involved in a small initiative in Massachusetts in the late 1990s. Vinyl membranes removed from roofs at the end of their service life were supplied to a local recycling company that blended them with other reclaimed plastics and created a road asphalt patching compound (*Figure 5*). Although an innovative and useful product, the volume of material that could be consumed was very limited.

Building on the experience and success of their Swiss parent company, which started recycling post-consumer vinyl membranes in the early 1990s, the company began experimenting with the concept in 2005.

Through trial and error and experimentation over a three-year period, the program has evolved to the point where it is now market ready. The culmination of these efforts came in the summer of 2008. A 250,000-sq-ft automotive facility in Michigan was to be reroofed. The facility had been recovered once already, and both layers of loose-laid PVC membrane and insulation needed to be removed prior to the installation of the new, mechanically attached PVC roof assembly. The 500,000 sq ft of vinyl alone would result in roughly 70 tons of debris. All involved parties – the building owner, the contractor, and the designer – were highly motivated to divert this massive amount of material from the local landfill.

After analyzing the samples of the competitive membranes in both layers of the existing roof, the supplier of the new material agreed to recycle all the membrane from this project. The contractor was responsible for removing the membrane and placing it into "gaylords" (heavy-duty 4-ft x 4-ft x 4-ft cardboard boxes) supplied by the membrane manufacturer (*Figure 6*). They were also responsible for palletizing the gaylords and loading them for shipment (*Figure 7*). The manufacturer of the new membrane was responsible for shipping the material to its third-party processing facility, the cost of processing the material into the required particle size, and shipping it to the manufacturer's production facility in Massachusetts.

At the completion of the project, the contractor noted that there was a slight learning curve for its crews at the start of the project. Rather than simply tearing everything off and dumping the mixed debris (membrane, insulation, ballast, etc.) into dumpsters, they had to first cut the membrane to the specified width (up to 39 in), make rolls of roughly 50 ft of membrane, tack-weld the flaps to prevent them from unrolling, and then place them in the boxes. This did increase their tear-off labor slightly. However, when they considered the savings in dumpster and tipping fees, they estimated

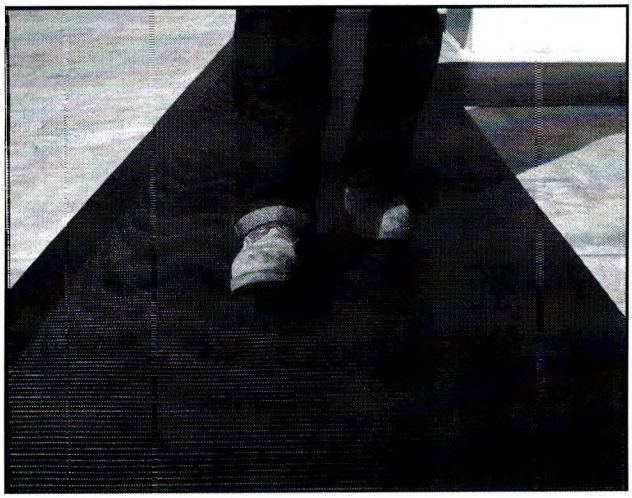

Figure 8 – Walkway material incorporating 25% postconsumer recycled vinyl roof membrane.

that they saved at least $5,000 by recycling the PVC membrane, net of the additional labor. This is consistent with the results on the more than a dozen projects completed to date, ranging in size from 20,000 sq ft to 160,000 sq ft. Under the model described above, in all cases, the contractor at the very least broke even versus the traditional disposal approach, and in most cases the contractor saved money.

This is, of course, a crucial element for the long-term success of the program. Fundamentally, everybody wants to do the right thing. However, in tough economic times, it can be difficult to justify paying a premium for being more ecological. By eliminating the economic barrier, there is no reason not to recycle a vinyl roof membrane at the end of its service life when it is technically feasible to do so.

Similarly, the manufacturer has found that the costs they assume, as described above, are typically offset by the savings in virgin raw materials.

The concept is economically viable throughout the entire value chain.

Closed-Loop Life Cycle

Once the material is processed and returned to the membrane manufacturer, it is used to produce new membrane products. To date, the bulk of the recycled material from old roofs has been used in the production of a 96-mil walkway membrane (*Figure 8*). More recently, it has also been used to produce a protection sheet for use in vegetated roof systems. Both products can accept loadings as high as 25% of the postconsumer recycled material, without affecting their performance. Both competitors' and the manufacturer's own materials are used in these applications.

The manufacturer has started to incorporate small amounts into the back side of new membrane. Only its own aged materials are used in the production of the roofing and waterproofing membranes. With the first European installations incorporating membranes with postconsumer recycled content approaching 15 years in service, no differences in performance have been observed compared to membranes produced exclusively with virgin raw materials.

All of these products will provide decades of service in their second life, essentially creating a closed loop that can, in principle, perpetuate itself time and again.

Thermal Insulation

The roof membrane is, of course, but one component of any roof replacement. On any insulated roof, the mass and volume of the thermal insulation will far exceed that of a thermoplastic PVC membrane. Much as with PVC membranes, plant trimmings from polystyrene insulations (both expanded [EPS] and extruded [XPS]) can be recycled back into new product. To date, manufacturers have not been able to cost-effectively recycle polystyrene back into new insulation at the end of its service life. However, with its high resistance to water absorption, extruded polystyrene is an ideal candidate for reuse if the roof membrane is to be replaced (*Figure 9*). Innovative marketing programs are being developed around systems incorporating recyclable PVC roof membranes and extruded polystyrene covered by long-term (up to 40 years) thermal retention warranties, providing building owners with long-lasting, extremely sustainable solutions to their roofing and waterproofing needs.

Polyisocyanurate insulation is not recycled. Plant scraps are, in some cases, used as a fuel in insulation plants. Like EPS, polyisocyanurate is sometimes reused at the end of a roof's service life in such applications as lining agricultural buildings, foundation waterproofing, and on occasion, it is ground up and used in concrete blocks or other nonfoam applications.

Learning From Others

As noted previously, the carpet industry has had considerable success with its CARE (Carpet America Recovery Effort) program. The program was established in 2002. From its founding, it has experienced double-digit growth annually, and to date, has diverted over one billion pounds of carpet from landfills. Having established that a cost-effective radius for collecting and processing materials is about 200 miles, CARE has expanded its network of collection sites from 5 to 56 over time. To some degree, it has become a victim of its own suc-

Figure 9 – Extruded polystyrene insulation being saved for reuse.

cess, and the industry is working intensely to develop alternative outlets for the product, as collections now exceed the demand for recycling into new carpet products.

During the PVC membrane trials, it was established that a cost-effective radius for shipping old membrane from a roof location to a processing site is approximately 700 miles. During the early stages of the program, a single processing company/location was used. As the program has expanded, additional sites have been or are in the process of being qualified. This expands the effective coverage area of the program to the eastern half of the U.S. and Canada. In 2009, efforts will be made to develop a similar network in the west. With the program still in its infancy, and considering that the market for thermoplastic PVC roof membranes continues to grow, the group does not anticipate supply surpassing demand for many years. However, some member companies have already begun development work on alternative outlets for the material in order to be ready for such an eventuality, should it arise.

Turning a Concept Into Reality

Not surprisingly, the most successful recycling projects throughout the trial phase were those that were planned out in advance and had the recycling process written into the project specifications.

The process should start with the condition assessment of any thermoplastic PVC roof. Once it has been decided that the existing roof needs replacement, the potential for recycling the membrane should be investigated. At this time, only loose-laid (ballasted, inverted, vegetated) and mechanically attached membranes are suitable for recycling. Although outlets for adhered PVC membranes exist in Europe, they are currently not available in North America. Consult with individual membrane suppliers for their specific requirements. Some may only recycle their own materials. Some may recycle competitors' PVC products, subject to prior analysis and approval.

Work with the manufacturer to develop clear guidelines as to each party's responsibilities in the process. Key items to consider include how the material is to be handled, stored on site, and prepared for shipping. These elements can be clearly spelled out

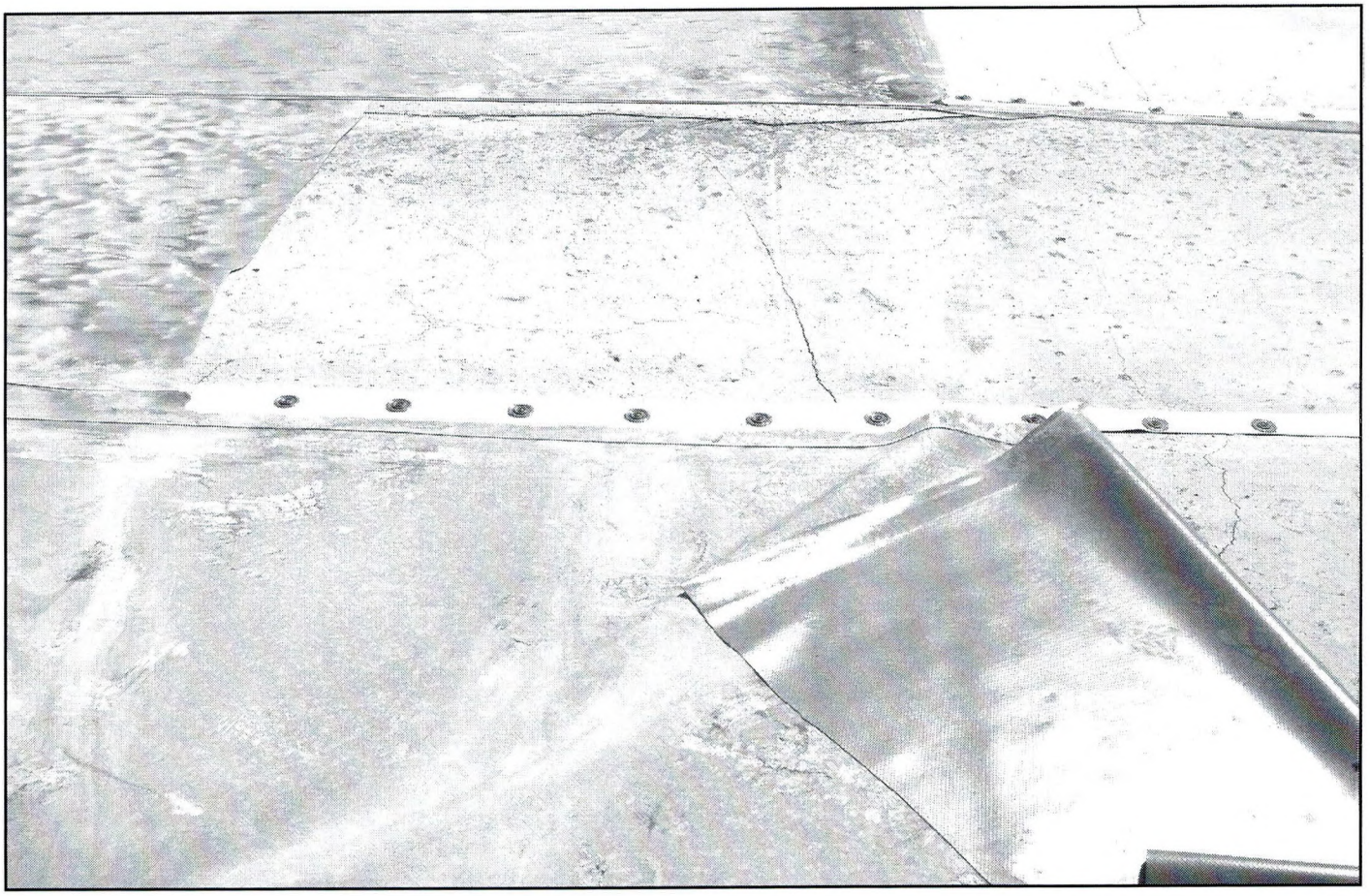

Figure 10 – Removal of a mechanically attached vinyl roof to be recycled.

in the project specifications; or conversely, more general language can be used and the contractor instructed to provide the detailed procedures with its bid documents on how it will carry out the process. One example of language that has been used follows:

> The existing roof membrane is to be recycled by the manufacturer of the replacement membrane. The contractor is responsible for all costs associated with removing the membrane, preparing it, and loading it for shipping, according to the manufacturer's published procedures.

Additionally, one may want to call for proof of recycling experience, noting a minimum number of projects, total square footage processed, etc.

Prebid and job start-up meetings are always advisable, but they are particularly important on recycling projects. Although the concepts involved and the steps to be carried out are quite simple, most contractors will be new to the process, and clear communication, particularly with regard to the manufacturer's requirements, is essential for a smooth, efficient project.

Similarly, consideration should be given to the potential reuse of the insulation. It should be noted, however, that whereas membrane recycling is managed through the manufacturer, insulation reuse is carried out through recycling companies/material brokers, with no involvement from the foam producer.

Designing for Recycling

Despite its success, an ongoing challenge for the CARE program is getting specifiers to design for recycling. The industry needs to do a better job of communicating to architects and interior designers the consequences of their design decisions today with regard to recycling carpets at the end of their service life.

A similar approach will need to be taken with regard to roofing. One key criterion when considering the recycling of commercial roof assemblies is the ability to separate the components (*Figure 10*). This is equally important for insulation reuse and for membrane recycling considerations. As noted previously, there are no means of recycling adhered membranes in North America, nor are there outlets for the reuse of adhered insulations. Therefore, in

designing for recycling, all components should be either loose-laid or mechanically attached.

Although much work is no doubt being done in other industry segments, at this time, the only commercial roofing membrane that has been proven to be recyclable at the end of its service life is vinyl.

CONCLUSIONS

Opinions vary, and there is no clear, universal definition of what sustainability is. There is, however, a broad, general consensus on some of the key tenets that are central to any definition of sustainability of roofing systems. These include extending roof-system lifespan, conserving energy, and minimizing the burden on the environment. Many systems, such as those based on exposed thermoplastic PVC roof membranes, have demonstrated decades-long service lives across North America. Between increases in the thicknesses of thermal insulation used, acceptance and implementation of cool roofing concepts, and the recognition of the benefits of air barriers in roofing systems, tremendous progress has been made with regard to reducing energy loss through roofs. Clearly, the industry has, by and large, addressed the first two tenets. The postconsumer recycling programs being developed by the members of Chemical Fabric and Films Association will, at least in the vinyl roofing segment, go a long way in addressing the latter tenet of minimizing the burden on the environment, thereby providing all stakeholders with fully sustainable roofing and waterproofing solutions.

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